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RADIATION VARIATION OF WELL, DRINKING AND THERMAL WATERS IN SANDIKLI REGION

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Abstract

In this study, we have measured the α/β concentration in drinking and thermal waters in Sandıklı, Afyon. Periodic samples are collected from 8 sources over sampling period 6 months. Samples are analyzed by WPC 9550 α/β proportional counter. We have compared the results with WHO (World Health Organization)'s standard recommendation results about drinking and thermal waters. In general, we found beta radioactivity values normal and alpha radioactivity values high.

Key Words: Radiation, α (Alpha), β (Beta), γ (Gamma), Radioactivity, Drinking and Thermal waters.

SANDIKLI BÖLGESİNDEKİ KAYNAK, İÇME VE KAPLICA SULARINDAKİ RADYASYON DEĞİŞİMİ

Özet

Bu çalışmada Sandıklı'daki içme ve termal sulardaki α/β konsantrasyonu ölçülmüştür. Periyodik olarak numuneler sekiz farklı su kaynağından altı aylık sure boyunca toplanmıştır. Numuneler WPC 9550 α/β orantılı sayacı ile analiz edilmiştir. Sonuçları, Dünya Sağlık Örgütü (WHO)'nün kaplıca ve içme suları için tavsiye ettiği standart değerlerle karşılaştırdık. Genel olarak, beta değerlerinin normal, alfa değerlerinin yüksek olduğu görülmüştür.

*Anahtar Kelimeler:*Radyasyon, α (Alfa), β (Beta), γ (Gamma), Radyoaktivite, İçme ve Kaplıca suları.

1. Introduction

Studies about radioactivity have been done since 1976, but α/β values in drinking and thermal waters have been out of these studies. Radon spreads α particles and Thorium spreads β particles. Radon exists in groundwater which emissions from rocks. Radon concentration depends on temperature, pressure, rain and earthquakes.

1.1. Radiation Sources

Radiation is one of the ways of transferring energy to the environment. According to transporting energy, there are two kinds of radiation; Ionizing and Non-ionizing radiation. Ionizing radiations have enough energy because they pull or transfer electron from another atoms. Ionizing radiations are important for human health and environment. There two kinds of ionizing radiations.

a) Direct ionizing radiation: These are alpha, beta, positron, proton and deuteron's charging particular radiations.

b) Indirect ionizing radiation: X-rays, gamma rays and neutron radiations. These radiations haven't got any charges.

Non ionizing radiations are light waves, high frequency radio waves and neutrino radiations from the space. Non- ionizing radiations are also called electromagnetic radiation. If energy scatters like electric field and magnetic field in vacuum, this is electromagnetic radiation (Scott, 1982).

If an unstable atom changes to stable equilibrium scatters ray or particular to the surrounding called radioactivity. Radioactivity is important to determine nuclear materials. Radiations have two effects on materials. One of them is ionization, the other is energy transfer. Roentgen is the unit of radiation amount. X and gamma rays ionized the materials. Roentgen based on this rule. This is called as ionization dose. Energy dose's unit is gray (Gy). If one kg mass transfers one joule energy, this radiation is gray. If we measure energy dose of radiation, we must determine one kg water's temperature (Bruno, 1983).

There are two kinds of radiation sources, one of them is natural and the other is artificial radiations. There are three Thorium groups of low level radiations in nature.

1) Cosmic rays (X-rays, gamma rays, neutron and proton radiations).
2) Uranium and Radium's radioactive isotopes.
3) Potasium-40, Carbon-14 radioactive isotopes which are being naturally in human body (Gesell, 1972).

In untreated ground-water systems, removal by adsorption would not be as rapid as in the aquifer due to the small surface area of the distribution system. Exposure from consumption of these supported, extremely short-lived progeny should be evaluated. Radon-220 and its progeny do not pose a similar problem primarily because the 54.5-second half-life of ^{220}Rn is too short to allow diffusion from the aquifer materials and the initial activities are much lower. Radon is used for ^{222}Rn forms from Radium-226 and we can show it like this;

$$^{226}\text{Ra} \longrightarrow {}^{222}\text{Rn} + {}^{4}\alpha\ ({}^{4}\text{He}) \qquad (1)$$

Radon is an inert gases. Radon's source Radium exists in soil and other materials. A person could not take Radon but he could take Radon's isotopes. There are two isotopes Rn, with half-lives long enough to be considered as drinking water radio nuclides. The first is ^{222}Rn which is the progeny of ^{226}Ra, called "radon" and has a life-life of 3.84 days. The second, ^{224}Ra was historically called "thorium" and has a half-life of 56 sec. The time delay from production to consumption of water of a few hours to a few days for water allows many decay half-lives for ^{220}Rn, and it is not observed in water supplies. Radon-222, henceforth simply Rn, is transported by water, and can lead to public exposures by being ingested and exposing the digestive system as well as by becoming airborne and exposing the lungs. When water is used for cleaning, dish-washing, bathing or clothes washing, Rn escapes from the water in to building air where it decays into α-emitting progeny. The resulting Rn progeny are charged and will frequently attach to aerosol particles in the air. The dust, cigarette smoke, or aerosol particles will then be inhaled and may become attached to the interior of the lung, bringing the α particle-emitting Rn progeny in to close association with the cell lining of the respiratory system (Archer et. al., 1979). Radon isotopes hold aerosols at the atmosphere and enter to the human body like this way. Radon's concentration in door is higher than outdoor. Radon's sources are shown in table 1.

Table 1. Radon's Sources in a Home.

Sources	Radon flux (Bq/day)
Instruction Materials	$70x10^3$
Water	$4x10^3$
Outdoor atmosphere	$9x10^3$
Natural gas	$3x10^3$
Liquid Petroleum Gases(LPG)	$0.2x10^3$

(Çelebi, 1989)

The occurrence of Rn in water is controlled by chemical concentration of Ra in the host soil on rock and by emissivity of Rn in to the water. The physical condition of the rock matrix appears to play a greater role in Rn production than does the concentration of parent Ra. Several investigators have examined the mechanisms influencing the release of Rn from rock grains and the transport of Rn through an aquifer (Andrews and Wood, 1972). Experimental and theoretical considerations indicate that diffusion along microcrystalline imperfections dominates the release of Rn in to the surrounding interstitial waters. The movement of Rn in water is governed by water transport rather than diffusion in most cases, cases in which the infiltration velocity rate is greater than 10^{-5} cm/sec. Radon produced from Ra in the surface of the soil and rock is released in to houses from water, soil gas, fuel gas and construction materials and outdoor air (Akerblom and Wilson, 1981). Both water and soil gas can be transported in to buildings trough cracks, drain holes, as well as water and fuel gas supply pipes (Scott, 1982). The Rn in the ground water is released as it is mixed with air in such indoor uses as cleaning, bathing and toilet flushing (Hess et. al., 1983). Soil gas will mix in to building air and then diffuse throughout the house. Radon from fuel gas enters building air from unvented heaters or stoves. Thus, the Rn concentration in air will depend on the sum of all Rn sources, the volume of the building and the ventilation rates of the building.

There a number of situations in which indoor α/β levels are especially elevated. These situations occur when the structure contains a stronger than usual source of α/β, or when the structure has especially low ventilation and infiltration rates or both. Rising heating and air conditioning costs in the last several years have encouraged people to reduce air infiltration rates.

1.2. Effects of Radiation on Living Organisms

Alpha and beta are nuclear radiations and also have masses and electrical charges. Alpha particles always have got positive charges; beta particles have got both positive and negative charges. Beta particles penetrate the human body about 10 mm. Alpha particles penetrate about 45 micron. X and gamma rays are in electromagnetic spectrum but they have high energy. Both of them can penetrate the material very deeply, so that they are used in medical sources prevalently (Hildingson, 1981).

Alpha particles are scattered by radioactive nuclei which 7500 times bigger than electron mass. Alpha particles go trough in materials very low, cause of influence with materials have been very much ion. Their velocities are stopped very quickly, have short distance in the environment and don't change their ways. Alpha particles become ionization while going through the air.

Ionization decreases after maximum value. In this station, Alpha particle transforms to Helium atom when it losts all of its energy. Alpha particles in the living organisms become very dangerous. Beta particles have different energy values and become large energy spectrum. Beta's energy separates between β-ray and anti-neutrino (Mcgregor et. al., 1980).

Cause of beta's small masses and negative charges, it collides with atom's orbital electrons and nuclear of atoms. While colliding with electron, beta particle gives all of its energy to the electron, pulls the electron and changes its own way. Beta particle goes in through the material with zigzag (Acar, 1987). It is shown in figure 1.

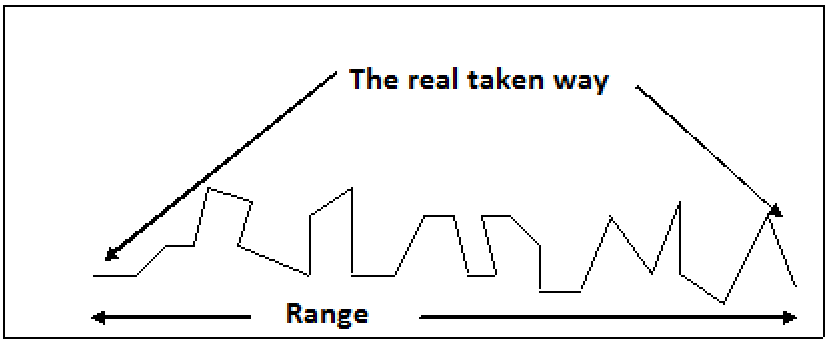

Figure 1. β – Particle's Range and the real taken Way.

2. Materials and Methods

To measure radioactive rays, we must either ionizing in gases or stimulating in solid materials. Ionizing rooms, Geiger-Muller counters and Proportional counters are examples for ionizing in gases systems. Oldest detector system working by gases is ionizing rooms. Radioactive rays ionize gases and then electrons and ions occur. In ionizing rooms beta particles have low current so that ionizing rooms aren't suitable counter for counting beta particles. α, β and γ rays can be counted by Geiger-Muller counters. There has been a high pulse in G.M counters. The most useful G.M counter type is cylinder shaped. There is an anode at the cylinder's axe made of tungsten wire. There is a gas pressure lower than atmosphere pressure in G.M counters (Acar, 1987).

At proportional counter detector has always a gas. In general Argon and methane gases mixture is used. These counters have got 2π or 4π geometer, so that counting efficiency is very high. 2π geometer counters only can be count ions come from above. 4π geometer counters count ions come from everywhere in the detector (Figure 2). In this study, we used WPC 9550 α/β proportional counter for counting α and β radioactivity values.

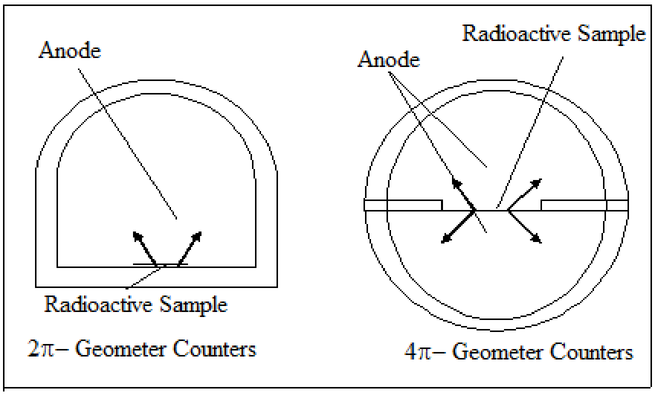

Figure 2. 2π and 4π Geometer Counters.

We calibrated WPC 9550 α/β proportional counter with KCI (Potassium Chloride) for determining beta activity. Because Potassium (K) scatters has natural beta particle. We calibrated WPC 9550 α/β proportional counter with Am-241 for determining alpha activity. Am-241 scatters only alpha particles. To determine α, β efficiency, we use below equation;

$$E = \frac{cpm}{dpm} x100 \qquad (2)$$

In the equation; E: Efficiency, Cpm: Count Per minute, Dpm: Disintegration per minute

$$\text{Total } \alpha \text{ or } \beta \text{ activity} = \frac{100 \text{ x c}}{2.22 \text{ x V x E}} pCi/L \qquad (3)$$

Here; C: count per minute (cpm), V: Amount of counting samples (g), E: Percentage of efficiency according to amount of taking samples (%).

3. Examining Samples and Results

Samples were normally taken at each water sources during each sampling run. Each well, drinking and thermal water was allowed to purge for at least 5 minute prior to sample collection. Purging was occurred by allowing full-pump flow to the holding tank or to a discharge pipe to the environment. Samples were collected as close to the well head as possible. The spigot was opened to produce a very slow, non-aerated stream of water. A sample vial containing 1 L of scintillation fluid was positioned in the water stream at an angle such that the water flowed gently down the side of the vial and pooled under the scintillation layer. Low agitation and immediate coverage by the scintillation layer reduced α/β loss to the atmosphere during sampling. The vials were immediately capped. Approximately 1 L of sample was collected, and the exact sample volume determined by weighing the vials before and after sampling and assuming unit density for water. And also we found these values for α and β activities; α values = 0.037 Bq/L = 0.999 pCi/L (1 Becquerel = 27 pCi) and β values = 0.37 Bq/L = 9.99 pCi/L.

α Particles must been 0.1 Bq = 2.7 pCi in a liter. β Particles must been 1 Bq = 27 pCi in a liter. But World Health Organization (WHO) suggest maximum 3 times of these values. These are the limit values for α and β. In other words; α values = 2,997 ≅ 3 pCi/L and β values = 29,97 ≅ 30 pCi/L.

Thermal waters are different from drinking waters and ground waters. Drinking waters' values are lower than the Thermal waters' values. As shown in figure 3 Sandıklı district's public drinking waters values are lower than Sandıklı district's thermal waters values.

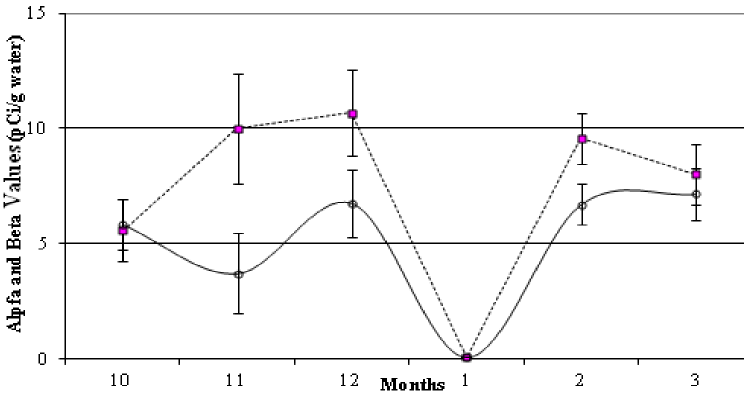

Figure 3. The variation of Sandıklı district's public drinking water's α and β activity values according to the months.

So α and β particles in thermal waters values are different from the above values. As a result finding beta values are normal but alpha values are higher than WHO's suggestion limited values.

α and β activity values in grab samples in thermal waters are too higher than WHO's suggestion values about drinking waters. But thermal water's α and β radioactivity values have been often higher like the Figure 3.

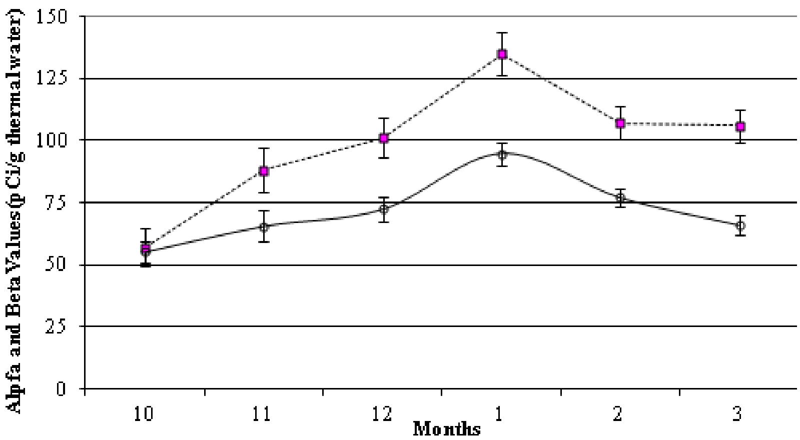

Figure 4. The variation of thermal water's α and β activity values according to the months.

So we can't say that thermal waters' α and β radioactivity values are very high according to other thermal waters measured in other places. Only one value which was measured in December 2000 is too high. In those days there have been an earthquake intensity of 4,2 Richter. May be, there will be a relationship between earthquakes and α-β activity values in thermal waters.

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